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5/01367
3-31-92

Re: U.S. Patent Application Serial No. 699,700
Filed: May 14, 1991
Entitled "APPARATUS AND METHOD FOR DETERMINING THE PERCENTAGE OF A FLUID IN A MIXTURE OF FLUIDS"

Dear Sir:

We now enclose the certified copy of the British Application No. 8,803,142 (Patent No. 2,215,061), for the purpose of claiming its priority.

Respectfully submitted,

Alton W. Payne
Reg. No. 30,580

AWP:rf
Enclosure

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"EXPRESS MAIL" CERTIFICATE

NUMBER: RB113081991

DATE OF DEPOSIT: November 18, 1991

I hereby certify that this paper or fee is being deposited with the United States Postal Service - "Express Mail Post Office To Addressee" Service under 37 CFR 1.10 on the above indicated date and is addressed to Commissioner of Patents and Trademarks, Washington, D.C. 20231

Rhonda Fairchild
Signature of Depositor

ATENTS ACT 1977

2215061

PATENTS FORM No. 1/77 (Revised 1982)
(Rules 16, 19)

11/02/88 B8694 PAT*** 10.00

The Comptroller
The Patent Office

REQUEST FOR GRANT OF A PATENT

8803142

THE GRANT OF A PATENT IS REQUESTED BY THE UNDERSIGNED ON THE BASIS OF THE PRESENT APPLICATION

I Applicant's or Agent's Reference *(Please insert if available)* P/8020201

II Title of Invention "METHOD AND APPARATUS FOR DETERMINING THE PERCENTAGE OF A FLUID IN A MIXTURE OF FLUIDS"

III Applicant or Applicants *(See note 2)*

Name (First or only applicant) AGAR CORPORATION LTD, ~~29789500~~

Country Cayman Islands State ADP Code No.

Address P.O. Box 866, Grand Cayman, Cayman Islands 425894 3001

Name (of second applicant, if more than one)

Country State

Address

IV Inventor (see note 3)

(a) ~~The applicant(s) is/are the sole/joint inventor(s)~~ or

(b) A statement on Patents Form No 7/77 is/~~will be~~ furnished

V Name of Agent (if any) *(See note 4)* J. A. KEMP + Co

ADP CODE NO 1149001

VI Address for Service (See note 5) 14 SOUTH SQUARE, GRAY'S INN, LONDON. WC1R 5EU

VII Declaration of Priority (See note 6)

Country	Filing date	File number

VIII The Application claims an earlier date under Section 8(3), 12(6), 15(4), or 37(4) (See note 7)

Earlier application or patent number .... and filing date ....

IX Check List *(To be filled in by applicant or agent)*

A The application contains the following number of sheet(s)

1 Request ......1...... Sheet(s)

2 Description ......17...... Sheet(s)

3 Claim(s) ......4...... Sheet(s)

4 Drawing(s) ......3 + 3...... Sheet(s)

INFORMAL

5 Abstract ......1...... Sheet(s)

B The application as filed is accompanied by:

1 Priority document ......NO......

2 Translation of priority document ......NO......

3 Request for Search ......YES......

4 Statement of Inventorship and Right to Grant ......YES......

X It is suggested that Figure No ......4...... of the drawings (if any) should accompany the abstract when published.

XI Signature *(See note 8)*

J. MILLER & CO., Agents for the Applicants.

NOTES:

1. This form, when completed, should be brought or sent to the Patent Office together with the prescribed fee and two copies of the description of the invention, and of any drawings.

2. Enter the name and address of each applicant. Names of individuals should be indicated in full and the surname or family name should be underlined. The names of all partners in a firm must be given in full. Bodies corporate should be designated by their corporate name and the country of incorporation and, where appropriate, the state of incorporation within that country should be entered where provided. Full corporate details, eg "a corporation organised and existing under the laws of the State of Delaware, United States of America," trading styles, eg "trading as xyz company", nationality, and former names, eg "formerly [known as] ABC Ltd." are not required and should not be given. Also enter applicant(s) ADP Code No. (if known).

3. Where the applicant or applicants is/are the sole inventor or the joint inventors, the declaration (a) to that effect at IV should be completed, and the alternative statement (b) deleted. If, however, this is not the case the declaration (a) should be struck out and a statement will then be required to be filed upon Patent Form No 7/77.

4. If the applicant has appointed an agent to act on his behalf, the agent's name and the address of his place of business should be indicated in the spaces available at V and VI. Also insert agent's ADP Code No. (if known) in the box provided.

5. An address for service in the United Kingdom to which all documents may be sent must be stated at VI. It is recommended that a telephone number be provided if an agent is not appointed.

6. The declaraton of priority at VII should state the date of the previous filing and the country in which it was made and indicate the file number, if available.

7. When an application is made by virtue of section 8(3), 12(6), 15(4) the appropriate section should be identified at VIII and the number of the earlier application or any patent granted thereon identified.

8. Attention is directed to rules 90 and 106 of the Patent Rules 1982.

9. Attention of applicants is drawn to the desirability of avoiding publication of inventions relating to any article, material or device intended or adapted for use in war (Official Secrets Acts, 1911 and 1920). In addition after an application for a patent has been filed at the Patent Office the comptroller will consider whether publication or communication of the invention should be prohibited or restricted under section 22 of the Act and will inform the applicant if such prohibition is necessary.

10. Applicants resident in the United Kingdom are also reminded that, under the provisions of section 23 applications may not be filed abroad without written permission or unless an application has been filed not less than six weeks previously in the United Kingdom for a patent for the same invention and no direction prohibiting publication or communication has been given or any such direction has been received.

PATENTS ACT 1977 2215061

PATENTS FORM No. 7/77 (Revised 1982)

(Rules 15, 82)

8803142

The Comptroller
The Patent Office
25 Southampton Buildings
London, WC2A 1AY

STATEMENT OF INVENTORSHIP AND OF RIGHT TO THE GRANT OF A PATENT

I Application No.

II Title "METHOD AND APPARATUS FOR DETERMINING THE PERCENTAGE OF A FLUID IN A MIXTURE OF FLUIDS"

III *I/We AGAR CORPORATION LTD.,

the applicant(s) in respect of the above mentioned application for a patent declare as follows:–

i) I/We believe the person(s) whose name(s) and address(es) are stated on the reverse side of this form (and supplementary sheet if necessary) is/are the inventor(s) of the invention in respect of which the above mentioned application is made;

ii) The derivation of my/our right to be granted a patent upon the said application is as follows:–

By virtue of employment

iii) I/We consent to the publication of the details contained herein to each of the inventors named on the reverse side of this form.

IV *Signature* (see Note 3)

J. Miller

J. MILLER & CO., Agents for the Applicants.

PLEASE SEE OVERLEAF.

V4922

JORAM AGAR,
West Bay Road,
Grand Cayman,
Cayman Islands.

3803939001

NOTES

1 The name(s) and address(es) of the inventor(s) are to be entered in the spaces provided alongside.

2 Where more than 3 inventors are to be named, the names of the 4th and any further inventors should be given on the reverse side of an additional blank copy of Patents Form No. 7/77 and attached to this form.

3 Attention is directed to rules 90 and 106 of the Patents Rules 1982.

4 The surnames or family names of individuals should be underlined.

"METHOD AND APPARATUS FOR DETERMINING THE PERCENTAGE OF A FLUID IN A MIXTURE OF FLUIDS"

The present invention relates to a method and an apparatus for determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit and, although the invention is not so restricted, it relates more particularly to the determination of the percentage of oil or water in an oil/water mixture.

The accuracy of net oil measurement is extremely important to buyers and sellers of oil. If the oil contains water, the buyer does not want to pay for the oil on the basis of the gross amount of liquid shipped to him. Rather, he wants to pay only for the net amount of oil present in the total volume delivered. Net oil measurement is also required in oil fields for royalty payments and in enhanced oil recovery fields for pumping rate control.

There are in the prior art a number of instruments which have been used to measure water content in an oil/water mixture. Most of such instruments in the prior art rely on the difference between the dielectric constant of water and the dielectric constant of oil. As such, the main problem with these devices is their inability to deal with mixtures where the water constituent of the mixture is in the continuous phase rather than the oil. By definition, the dielectric constant is the ratio of the capacitance of a

capacitor field with a given dielectric to that of the same capacitor having only a vacuum as the dielectric. Therefore, in using the devices for oil/water measurement, when water is the continuous phase, the instrument will show a maximum value because the electric path between the two parallel plates of the capacitor will be shorted by the water in continuous phase. This is so even though oil may still comprise some 40 to 50 percent or more of the overall mixture.

A few techniques are available to measure the electrical properties of the mixture. For example, the conductivity of the mixture may be measured at a high frequency. While these techniques avoid the saturation effect which is typical of measuring capacitance, they produce two distinct, non-linear curves or families of curves of output signal in which,for example, current may be plotted against the percentage of water in the mixture. These curves may be empirically or theoretically derived. The first set of these curves is for the case where the water is in the continuous phase, while the second set of these curves is for where oil is the continuous phase. It should be understood that the step jump between these curves does not occur at a predetermined oil/water ratio. Other variables are involved including surface tension, and the amount of emulsifying chemicals present.

The present invention is based upon the discovery that one of the said variables is droplet size since the latter has a marked effect on the apparent conductivity of the mixture and thus the energy absorbed. Droplet size has been found to be determined by the shearing velocity, viscosity and surface tension of the mixture, but the most critical of these parameters is velocity.

According, therefore, to the present invention, there is provided a method of determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit, the said method comprising obtaining a measurement of at least one electrical property of the mixture in said region, measuring the speed of flow of the mixture in said region, and employing the said measurement and the speed of flow to derive the said percentage.

Since the speed of flow of the mixture is used in the derivation of the said percentage, an automatic correction is provided for the effects of variation in the shape and size of the particles.

Preferably, the temperature of the said mixture in the said region is obtained and is employed in the calculation of the said percentage.

The mixture is preferably a mixture of first and second liquids such that, when the or a said electrical

property is plotted against the said percentage, two data curves, or families of data curves,are obtained which are separated from each other and which respectively represent the first liquid in the continuous phase and the second liquid in the continuous phase.

The said first and second liquids may be respectively water and oil.

The derivation of the said percentage preferably involves determining whether the first or second liquid is in the continuous phase, selecting the appropriate data curve, and obtaining a reading from the latter.

Preferably, the determination as to whether the first or second liquid is in the continuous phase is effected by comparing the said measurement of the electrical property or properties to a predetermined value, one data curve or family of curves being selected when the said measurement is above the predetermined value, and the other data curve or family of curves being selected when the said measurement is below the predetermined value.

In the case of an oil/water mixture the step jump from one family of curves to the other may occur when the amount of water in the mixture is in the range of 35 to 75 percent of the total. Thus, just measuring the energy absorption properties of the mixture is not the complete solution. Because there are two distinct sets of curves

or equations, it is necessary to determine which curve or equation is to be used in calculating the percentage of water present.

As indicated above, the step jump occurs in the data when the mixture changes over from oil being in the continuous phase to water being in the continuous phase. It is very desirable to eliminate this step jump from the data and to linearize the two distinct curves or families of curves.

It should be apparent that the step jump represents a rapid change in the conductivity of the mixture. This change in conductivity may be measured by a conductivity meter or energy absorption detector, usually in units of milliamps of output. This information may be fed to a comparator to select one of two memories which are respectively programmed with data relating to water being in the continuous phase and to oil being in the continuous phase. Generally, it has been determined that if an oil/water monitor in a particular configuration measures a current of, say, less than 5 milliamps, then oil is in the continuous phase, and if a current greater than 5 milliamps is measured, then water is in the continuous phase. The linearized output from the selected memory may be fed to an output stage, display or multiplier. The multiplier may be used to determine the net water content of the mixture by multiplying the

flow rate by the percentage of water present. The difference between the mass flow rate and the net water content equals the net oil present.

According, therefore, to another aspect of the present invention, there is provided apparatus for determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit, said apparatus comprising electrical property measuring means for obtaining a measurement of an electrical property or properties of the mixture in said region; flow measuring means for measuring the speed of flow of the mixture in said region; and calculator means arranged to receive signals from the electrical property measuring means and from the flow measuring means and to calculate the said percentage therefrom.

The apparatus preferably comprises temperature measuring means for measuring the temperature of the mixture in said region, the calculator means being arranged to receive signals from all said measuring means and to calculate the said percentage therefrom.

The calculator means may comprise memory means programmed with data relating to whether a first liquid or a second liquid of said mixture is in the continuous phase, the calculator means having data selection means arranged to select the data to be employed in calculating the said percentage.

The data selection means may comprise a comparator arranged to select the data to be employed in calculating the said percentage, the comparator comparing the said measurement with a predetermined value and selecting the data in accordance with whether the said measurement is above or below the predetermined

value.

The flow measuring means may be arranged to send a signal representative of flow through the conduit to a multiplier where the flow is multiplied by the said percentage to produce an indication of the flow of the fluid whose percentage has been calculated.

A substractor may be provided for subtracting the last-mentioned flow from the total flow.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figures 1 and 2 are sketches illustrating respectively the effect of large and small droplets on the conductivity of an oil/water mixture,

Figure 3 is an elevational view of a probe and oil/water monitor which may be used in an apparatus according to the present invention,

Figure 4 is a schematic diagram of an embodiment of an apparatus according to the present invention,

Figure 5 is a graph of two empirically derived sets of curves in which current absorbed or admittance is plotted against the percentage of water in an oil/water mixture, and

Figure 6 is a schematic view of a circuit which may be used in an oil/water monitor forming part of an apparatus according to the present invention.

As indicated above, the present invention is based on the discovery that the measurement of the conductivity or other electrical property of a mixture of fluids, such as an oil/water mixture, flowing through a predetermined region of a conduit is affected by the size and shape of the droplets of one liquid of the mixture, e.g. oil, in a continuous phase of the other or another liquid of the mixture. e.g, water. This is illustrated in Figures 1 and 2.

In Figure 1 there is shown diagrammatically a conductivity meter 1 having spaced apart positive and negative electrodes 2, 3 respectively. An oil/water mixture 4 comprising 30% oil and 70% water flows through the space between the electrodes 2, 3. The mixture 4 is shown as having water in the continuous phase and large oil droplets 5. The lines of force between the electrodes 2, 3 are shown at 6 and,as will be seen, a high proportion of the lines of force 6 are interrupted by the large oil droplets 5, so that the conductivity reading produced by the conductivity meter 1 will be below the true value.

Figure 2 is a view similar to Figure 1 and also indicating the passage through the meter 1 and an oil/water mixture 4 comprising 30% oil and 70% water. In this case, however, the mixture 4 contains tiny oil droplets 7. As a result, the lines of force 6 are hardly affected by the tiny oil droplets

7 and consequently the reading produced by the conductivity meter 1 will be above the true value.

Thus although it is not obvious at first sight that the apparent conductivity of an oil/water mixture, which is flowing through a conduit and which has water in the continuous phase, is dependent upon the size, shape and distribution of the oil droplets, this is certainly the case. It has been found indeed, that the apparent conductivity, and thus the energy absorbed by the fluid, is inversely proportional to droplet size. Droplet size, however, is itself determined by the shearing velocity, viscosity and surface tension of the fluid, and velocity is the most important of these factors.

Accordingly, the current (I) that is measured by the conductivity meter 1 as passing through the oil/water mixture 4 is a function (f) of the percentage of water (W) in the mixture 4 and the shearing velocity or velocity of flow (v) which is itself functionally related to the particle size.

Thus $I = f\ (W;\ v)$ (1)

Consequently, by measuring both the velocity of flow v and the current I, a set of simultaneous equations can be produced which can be solved to find the percentage of water W. The parameters of the calculations can be found

empirically or by calculation.

A third parameter may also be needed if the temperature (T) of the measured mixture varies widely. Equation (1) then needs to be rewritten as

$$I = f\ (W;\ v;\ T) \qquad (2).$$

In order to solve equation (2), the temperature of the mixture 4 must be measured and three simultaneous equations must be solved.

Turning now to Figure 3, there is shown therein a probe 10 mounted within a conduit 12. The conduit 12 has an inlet 11 through which an oil/water mixture passes into the conduit 12, the oil/water mixture passing out of the conduit 12 through an outlet end 13 of the latter. Energy is transmitted into the oil/water mixture in the conduit 12 from an oil/water monitor 14 and through the probe 10. In such manner, an oil/water monitor 14 can measure the electrical properties of the mixture flowing through conduit 12. This could, for example, be performed by measuring the conductivity, energy absorption,capacitance, admittance and/or impedance of the oil/water mixture by means of the oil/water monitor 14. As used herein the term "electrical properties" includes all of such terms singly or in combination.

One such oil/water monitor 14, which can be used with the present invention, is the Agar OW-101 water in oil monitor.

The Agar OW-101 measures the energy absorption properties of the oil/water mixture, rather than just the capacitance thereof. It is programmed with an empirically generated curve in which current in milliamps is plotted against the percentage of water. The curve contains a pronounced step jump as the mixture goes from oil being in the continuous phase to water being in the continuous phase. Because the location of the step is affected by a number of variables, it can be difficult to determine precisely what percentage of water is present.

Another device which may be used for oil/water monitor 14 is the Invalco Model No. CX-745-200GP.

United States Patent No. 4,503,383 (Agar et al) shows another device which can be used in place of the oil/water monitor 14.

Still another device which can be used as an oil/water monitor 14 is shown schematically in Figure 6. It includes an alternating current generator 15, a capacitor 17 and an ammeter 19. The capacitor 17 should be in the form of a probe which can be inserted into the oil/water mixture. The ammeter 19 measures current [I] so that when the water is in the continuous phase, the circuit can be defined by the equation:

$$I = V/R$$

which is Ohm's Law, where I is the current through the

ammeter 19, V is the voltage of the generator 15, and R is the effective resistance of the oil/water mixture.

When oil is in the continuous phase, the circuit can be defined by the equation:

$$I = Vj\omega c$$

where "j" is the square root of -1, "ω" represents the radial frequency and "c" represents the capacitance of the probe with the mixture inside it. Thus there can be theoretically derived two distinct curves or equations representing some electrical property plotted against the percentage of water present.

It is known that the effective capacitance of a parallel plates capacitor is given by the equation:

$$C = KEA/D$$

where "C" is the effective capacitance, "K" is a dimensional constant, "E" is the dielectric constant of a medium such as an oil/water mixture between the plates of the capacitor, "A" is the area of the plates and "D" is the distance between the plates. It is further known that the effective resistance of a medium contained between the two plates of the capacitor is given by the equation:

$$R = D/AG$$

where "R" is the effective resistance, "D" is the distance between the plates, "A" is the area of the plates and "G" is the conductivity of the medium. Because both the dielectric constant and the conductivity of the medium are proportional to the percentage of water present in the medium, the derivation of two distinct equations is possible. However, the dielectric constant and conductivity of the medium depend not only on the percentages of water and oil present, but also on which constituent is in the continuous phase. As mentioned earlier, the constituent which is in the continuous phase is affected by a number of other variables. Therefore, it is probably simpler to use the empirically generated curves shown in Figure 5.

The current or electrical signal generated in the oil/water monitor 14 is transmitted to a zero and span adjusters 16 (Figure 4) which allows the apparatus to be calibrated. From the zero and span adjusters 16 the data is transmitted to an analog to digital converter and calculator 18 and to a comparator 20. The comparator 20 uses this information to select one of two memories, namely either a continuous water phase memory 22 or a continuous oil phase memory 24. The calculator 18 also receives a velocity signal "v" from a digitizer 21 which digitizes an analog signal received from a flow meter 32 in the conduit 12, Additionally, the digitizer 21, and consequently the

calculator 18, may receive a temperature signal from a temperature measuring device 29 disposed in the conduit 12. The temperature measuring device 29 can be a thermocouple, a platinum resistance thermometer, a thermistor, or any similar device.

The continuous water phase memory 22 and the continuous oil phase memory 24 are programmed with families of curves 23 and 25 respectively as shown in Figure 5. These curves can be arrived at empirically, or theoretically. Curves 23 and 25 show some electrical signal plotted against the percentage of water present in the mixture at different flow velocities. The electrical signal may be in the form of a measurement of current, voltage, frequency, energy, conductivity, capacitance, admittance, impedance or the like, or any combination thereof. It should be recognized that the families of curves 23 and 25 represent two separate and distinct equations. It will be noted that the curves 23 and 25 have been projected, as shown by dotted lines, past the points where they intersect a step jump 27.

The comparator 20 will normally be a microprocessor or other computing device which compares the measured electrical signal shown in Figure 5 as a current with a predetermined value, say 5 milliamps. If the measured current is greater than the predetermined value, then water is in the continuous phase and the comparator 20 selects the right hand set of curves 23. If the measured current is less than the predetermined value, then the oil is in the

continuous phase and the comparator 20 selects the left hand set of curves 25.

The data transmitted from the oil/water monitor 14 provides the comparator 20 with the amount of current measured so that the comparator 20 can compare that value to the predetermined value.

Depending on which phase memory 22 or 24 is selected, the data is transmitted from the calculator 18 to that particular phase memory 22 or 24 where the amount of current is used to determine the percentage of water present by the way of the respective curve 23 or curve 25. The digitized data representing the percentage of water present is then transmitted to a multiplier 26 and simultaneously, to a digital to analog converter 28. The data from the digital to analog converter 28 is then transmitted to a meter 30 where the percent of water can be directly read. The data from the phase memory 24 is transmitted to a digital display 31 which may be constituted by a liquid crystal digital display of the linearized percentage of water.

The flow rate of the oil/water mixture flowing through the conduit 12 is measured by the flow meter 32. The flow meter 32 is preferably a positive displacement type flow meter or some other high accuracy type flow meter. A signal from the flow meter 32 is transmitted simultaneously via a scaler 33 to the multiplier 26, a subtractor 34 and a gross flow totalizer 36. The gross flow totalizer 36 keeps a running tabulation of the total volume pumped through the conduit 12. The gross flow data transmitted

from the flow meter 32 to the multiplier 26 is multiplied by the percentage of water data transmitted to the multiplier 26 from the memories 22 and 24. The data is then transmitted from the multiplier 26 simultaneously to a net water totalizer 38 and to the subtractor 34. The net water totalizer 38 keeps a running tabulation of the total amount of water which has been pumped through the conduit 12. Within the subtractor 34,the total water volume is substracted from the gross flow, the result being transmitted to the net oil totalizer 40. The net oil totalizer 40 keeps a running tabulation of the total volume of oil which has been pumped through the conduit 12.

The graph of Figure 5 depicts a somewhat typical step jump 27 between the two non-linear sets of curves 23 and 25 which are generated when oil/water ratios are determined by measuring the electrical properties of the mixture. It is highly desirable to eliminate the step jump 27 from the data. It is also highly desirable to linearise the data. This is accomplished through the use of the comparator 20, the memories 22 and 24, and the calculator 18. Further, by relying on other electrical properties of the oil/water mixture such as energy absorption, rather than the dielectric constant alone, a measurement may be made of the ratio of oil to water regardless of which

component is in the continuous phase up to and including the situation where there is no true mixture and 100 percent of the volume is water.

For purposes of clarification, the component in the continuous phase can be defined as that liquid which contains and surrounds the droplets of the second liquid such that the second liquid is present within the first liquid in the form of individual, discrete units.

CLAIMS

1. A method of determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit, the said method comprising obtaining a measurement of at least one electrical property of the mixture in said region, measuring the speed of flow of the mixture in said region, and employing the said measurement and the speed of flow to derive the said percentage.

2. A method as claimed in claim 1 in which the temperature of the said mixture in the said region is obtained and is employed in the calculation of the said percentage.

3. A method as claimed in claim 1 or 2 in which the mixture is a mixture of first and second liquids such that, when the or a said electrical property is plotted against the said percentage, two data curves, or families of data curves, are obtained which are separated from each other and which respectively represent the first liquid in the continuous phase and the second liquid in the continuous phase.

4. A method as claimed in claim 3 in which the said first and second liquids are respectively water and oil.

5. A method as claimed in claim 3 or 4 in which the derivation of the said percentage involves determining whether the first or second liquid is in the continuous phase, selecting the appropriate data curve, and obtaining a reading from the latter.

6. A method as claimed in claim 5 in which the determination as to whether the first or second liquid is in the continuous phase is effected by comparing the said measurement of the electrical property or properties to a predetermined value, one data curve or family of curves being selected when the said measurement is above the predetermined value, and the other data curve or family of curves being selected when the said measurement is below the predetermined value.

7. Apparatus for determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit, said apparatus comprising electrical property measuring means for obtaining a measurement of an electrical property or properties of the mixture in said region; flow measuring means for measuring the speed of flow of the mixture in said region; and calculator means arranged to receive signals from the electrical property measuring means and from the flow measuring means and to calculate the said percentage therefrom.

8. Apparatus as claimed in claim 7 in which the apparatus comprises temperature measuring means for measuring the temperature of the mixture in said region, the calculator means being arranged to receive signals from all said measuring means and to calculate the said percentage therefrom.

9. Apparatus as claimed in claim 7 or 8 in which the calculator means comprises memory means programmed with data relating to whether a first liquid or a second liquid of said mixture is in the continuous phase, the calculator means having data selection means arranged to select the data to be employed in calculating the said percentage.

10. Apparatus as claimed in claim 10 in which the data selection means comprises a comparator arranged to select the data to be employed in calculating the said percentage, the comparator comparing the said measurement with a predetermined value and selecting the data in accordance with whether the said measurement is above or below the predetermined value.

11. Apparatus as claimed in any of claims 7-10 in which the flow measuring means is arranged to send a signal representative of flow through the conduit to a multiplier where the flow is multiplied by the said percentage to produce an indication of the flow of the fluid whose percentage has been calculated.

12. Apparatus as claimed in claim 11 comprising a subtractor for subtracting the last-mentioned flow from the total flow.

13. A method of determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit substantially as hereinbefore described with reference to the accompanying drawings.

14. Apparatus for determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

15. Any novel integer or step, or combination of integers or steps, hereinbefore described and/or as shown in the accompanying drawings, irrespective of whether the present claim is within the scope of, or relates to the same or a different invention from that of, the preceding claims.

2215061

ABSTRACT

"METHOD AND APPARATUS FOR DETERMINING THE PERCENTAGE OF A FLUID IN A MIXTURE OF FLUIDS"

Apparatus for determining the percentage of a fluid present in a mixture of fluids flowing through a predetermined region of a conduit (12), said apparatus comprising electrical property measuring means (10,14) for obtaining a measurement of an electrical property or properties of the mixture in said region; flow measuring means (32) for measuring the speed of flow of the mixture in said region; and calculator means (18,20,22,24,28,30) arranged to receive signals from the electrical property measuring means (10,14) and from the flow measuring means (32) and to calculate the said percentage therefrom.

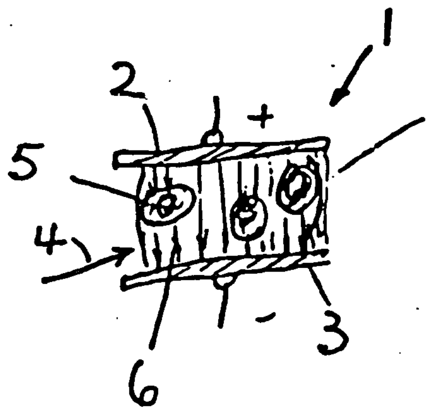

FIG 1

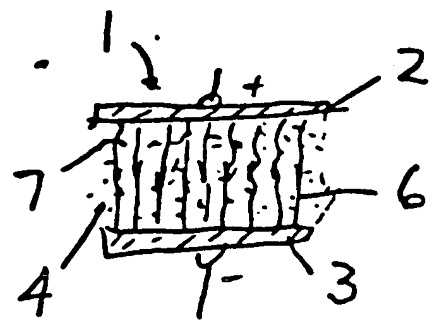

FIG 2

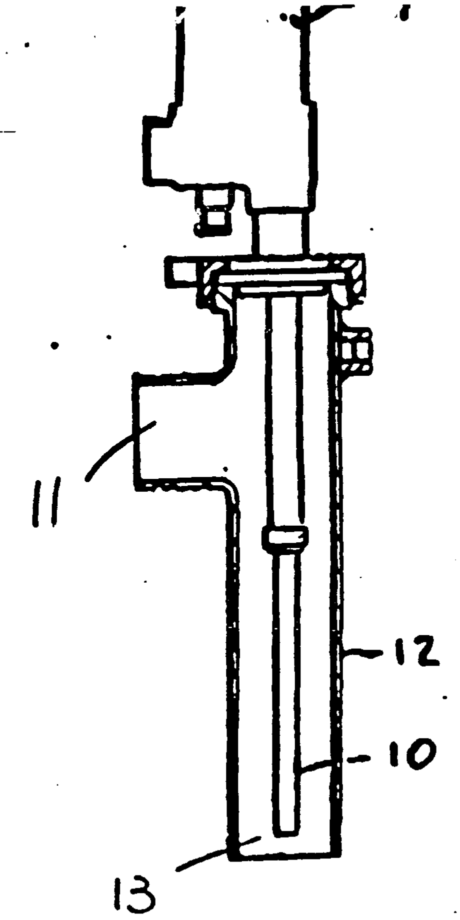

FIG.3

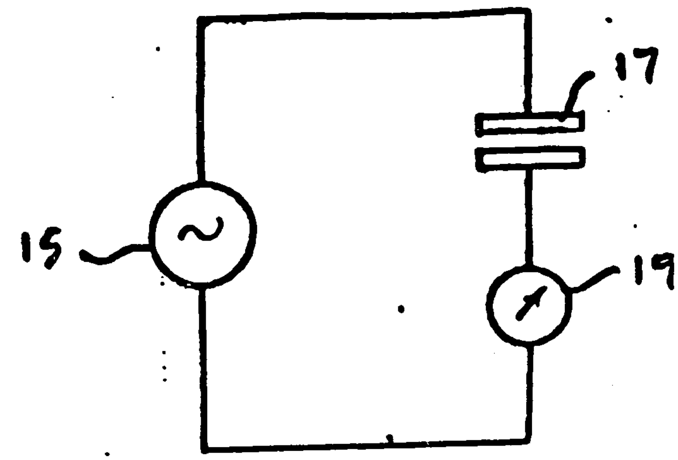

FIG. 6

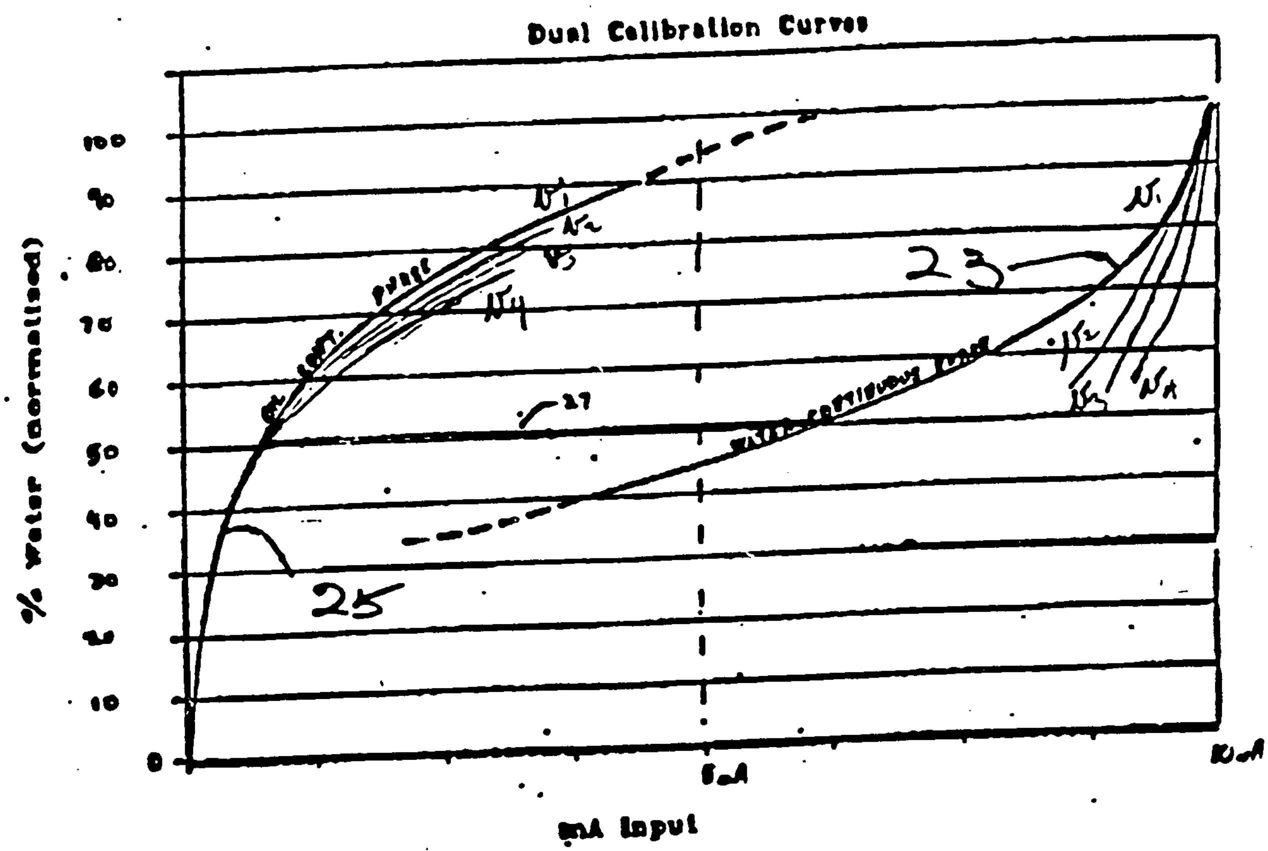

FIG. 5

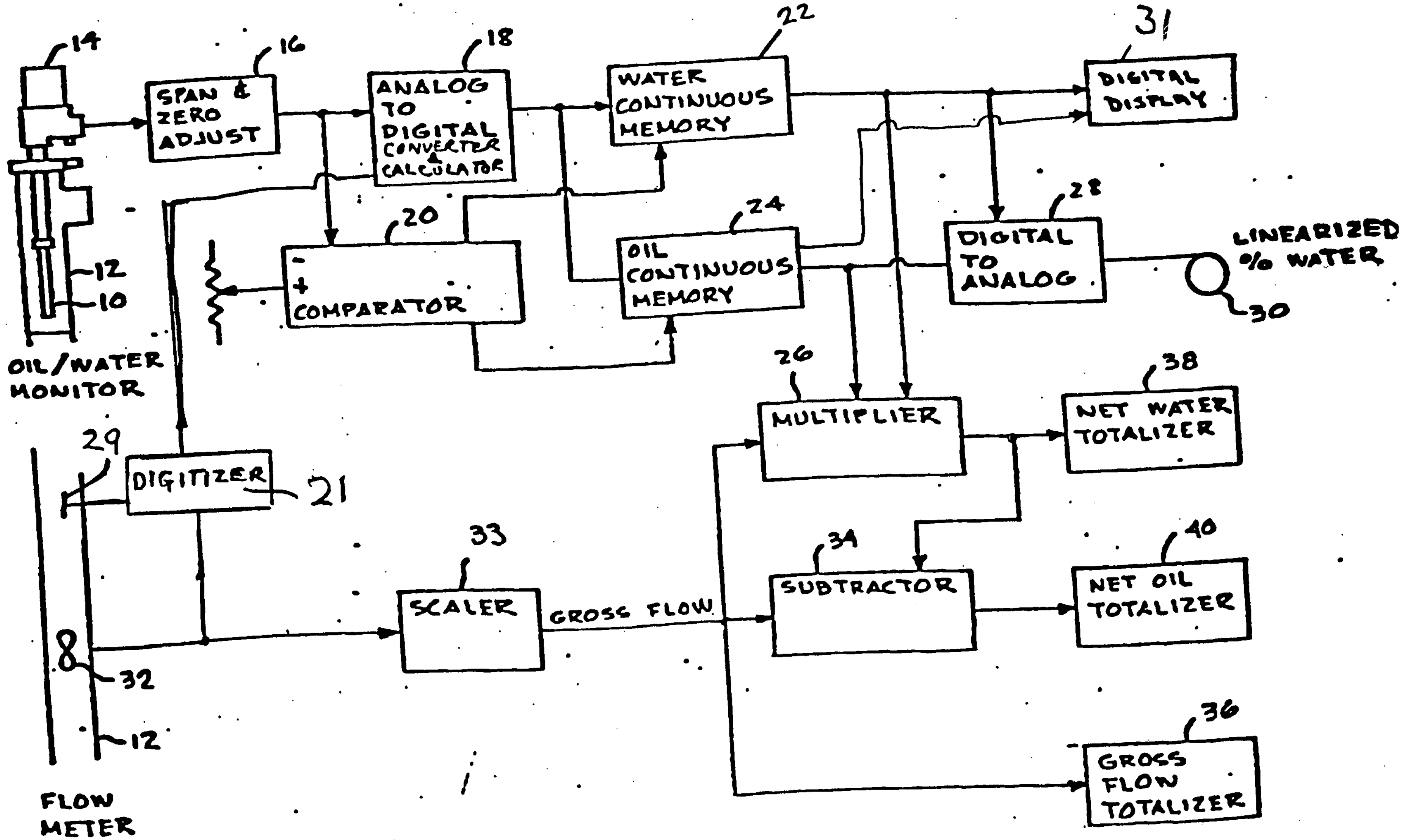
14
16
SPAN & ZERO ADJUST
18
ANALOG TO DIGITAL CONVERTER & CALCULATOR
22
WATER CONTINUOUS MEMORY
31
DIGITAL DISPLAY
20
- + COMPARATOR
24
OIL CONTINUOUS MEMORY
28
DIGITAL TO ANALOG
LINEARIZED % WATER
30
12
10
OIL/WATER MONITOR
26
MULTIPLIER
38
NET WATER TOTALIZER
29
DIGITIZER
21
33
SCALER
GROSS FLOW
34
SUBTRACTOR
40
NET OIL TOTALIZER
8
32
12
36
GROSS FLOW TOTALIZER
FLOW METER

FIG. 4